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Norton County, Kansas

National Eutrophication Survey, Corvallis, Oreg

Prepared for

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REPORT

ON

NORTON RESERVOIR

NORTON COUNTY

KANSAS

EPA REGION VII

WORKING PAPER No. 520

WITH THE COOPERATION OF THE

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT

AND THE

KANSAS NATIONAL GUARD

APRIL, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Kansas Division of Environmental Health provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Albin L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

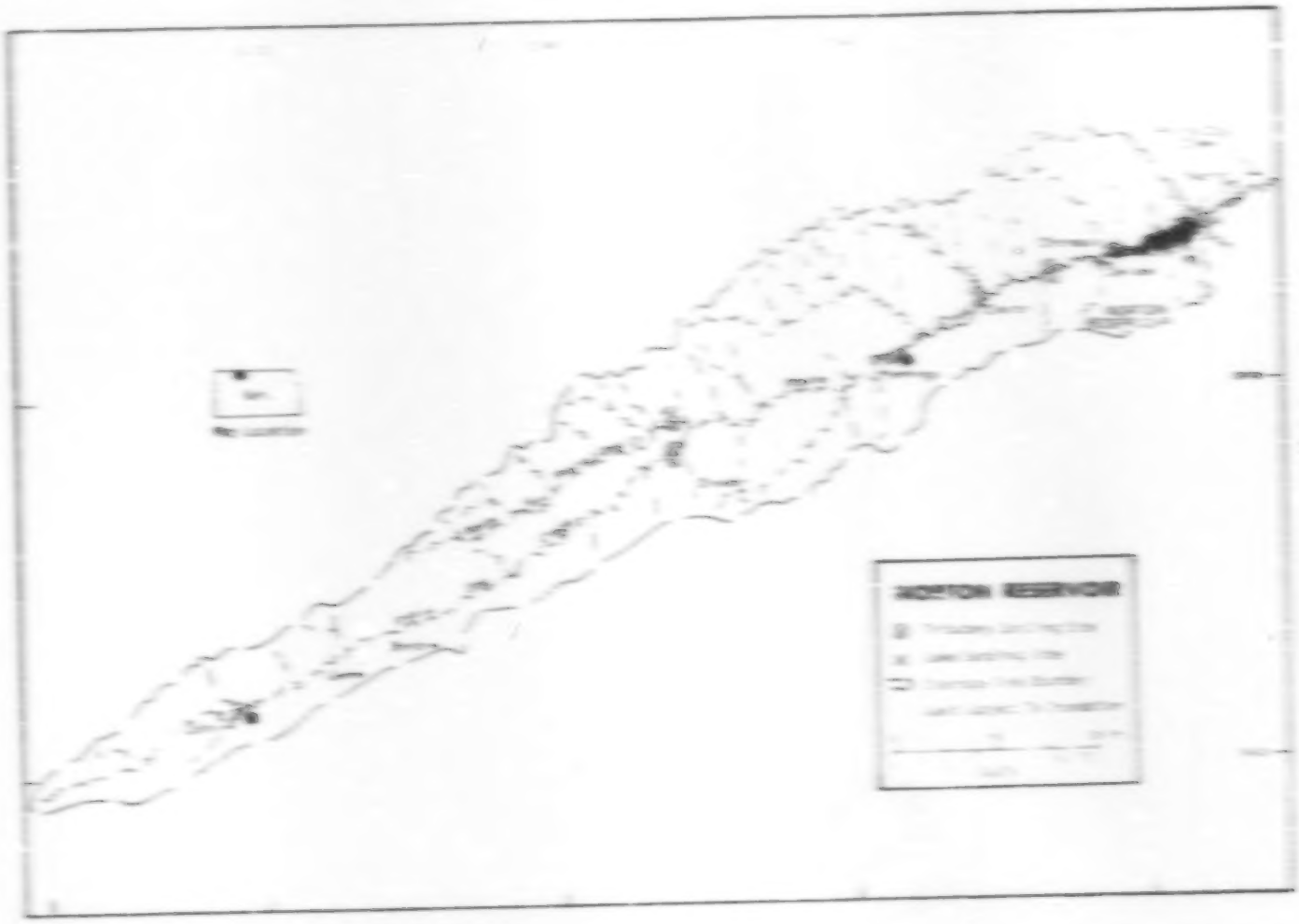
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

STATE OF KANSAS

NAME	COUNTY
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Pottawatomie, Riley
Wilson	Russell

NORTON RESERVOIR
Bellvale



NORTON RESERVOIR

STORET NO. 2010

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Norton Reservoir is potentially eutrophic. However, the reservoir becomes quite turbid during periods of runoff, and primary productivity is intermittently light-limited (Kring, 1977).

This water body ranked eighth in overall trophic quality when the 15 Kansas reservoirs sampled in 1974 were compared using a combination of six water quality parameters*. Thirteen of the reservoirs had less median total phosphorus, 11 had less and one had the same median dissolved orthophosphorus, one had less median inorganic nitrogen, 13 had less mean chlorophyll a, and five had greater mean Secchi disc transparency.

Survey limnologists did not observe surface concentrations of algae but noted emergent vegetation along the shoreline at station 2 in June. However, phytoplankton numbers in June indicate a near-bloom condition at that time (see page 7).

B. Rate-Limiting Nutrient:

The algal assay results indicate Norton Reservoir was nitrogen limited at the time the sample was taken (04/15/74). The reservoir data indicate nitrogen limitation at all sampling stations and

* See Appendix A.

times; however, primary productivity is light-limited at times rather than nutrient-limited.

C. Nutrient Controllability:

1. Point sources--The wastewater treatment plant at Jennings contributed an estimated 2.6% of the total phosphorus load to Norton Reservoir during the sampling year. In addition, the Colby wastewater facility of unknown nutrient significance is located some 90 kilometers upstream from the reservoir. Further investigation would be needed to determine the significance of nutrients contributed by Colby.

The present phosphorus loading of 1.26 g/m^2/year is 3.7 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). However, the level of the reservoir averaged about five meters below the conservation pool level during the sampling year, and the area of the reservoir at that level is not known (Kring, 1977). Obviously, the area was less than the 8.86 square kilometers indicated on page 4, so the actual areal phosphorus loading was to some unknown degree greater than that calculated. In any case, even complete removal of phosphorus at the Jennings wastewater treatment plant would not reduce the loading to any great extent, and on the basis of survey data, it appears that a significant improvement in the trophic condition of the reservoir would

result only if the 8,000 kg phosphorus load in Prairie Dog Creek can be substantially reduced.

F. Non-point sources--Non-point sources accounted for 97.4% of the total phosphorus load during the sampling year. Prairie Dog Creek contributed 71.9%, and the minor tributaries and immediate drainage contributed an estimated 25.1%.

Part of the non-point source load in Prairie Dog Creek may have been due to the Colby wastewater treatment plant; however, the phosphorus export rate of the creek was low and indicates relatively little point-source impact (see page 12). Agriculture is the dominant land-use practice around the reservoir and may contribute significantly to the nutrient loads. Additional study would be needed to evaluate the contribution and controllability of nutrients from such sources.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[1]

A. Morphometry[11]:

1. Surface area: 8,86 kilometers^2.
2. Mean depth: 5.0 meters.
3. Maximum depth: 15.0 meters.
4. Volume: 44.32 x 10^6 m^3.
5. Nine-year median hydraulic retention time: 1.8 years (based on mean volume).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Prairie Dog Creek	1,528.1	0.740
Minor tributaries & immediate drainage -	234.7	0.278
Totals	1,762.8	1.018

2. Outlet -

Prairie Dog Creek	1,771.6**	0.623

C. Precipitation***:

1. Year of sampling: 43.7 centimeters.
2. Mean annual: 57.8 centimeters.

[Table of metric conversions--Appendix B.
]] At conservation pool level; Kring, 1977.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Norton Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at one station in April and at two stations in June and September (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 3.0 meters at station 1, 5.5 meters at station 2, and 1.5 meters at station 3.

The sampling results are presented in full in Appendix B and are summarized in the following table.

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
06/13/74	1. Ankistrodesmus sp.	4,700
	2. Chroomonas sp.	3,817
	3. Stephanodiscus sp.	1,271
	4. Cryptomonas sp.	1,222
	5. Crucigenia sp.	1,171
	Other genera	2,899
	Total	14,950
08/28/74	1. Melosira sp.	11,923
	2. Euglenytes	6,248
	3. Chlamydomonas sp.	5,675
	4. Chroomonas sp.	1,562
	5. Oocystis sp.	1,041
	Other genera	2,083
	Total	28,532
09/30/74	1. Merismopedia sp.	1,037
	2. Scenedesmus sp.	695
	3. Microcystis sp.	645
	4. Crucigenia sp.	645
	5. Ankistrodesmus sp.	645
	Other genera	3,427
	Total	7,054

f. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (mg/l)
04/15/74	1	11.3
	2	-
	3	-
06/26/74	1	-
	2	35.5
	3	8.9
09/30/74	1	-
	2	22.9
	3	26.2

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.060	0.119	7.6
0.060 P	0.110	0.119	9.4
0.060 P + 1.0 N	0.110	1.119	29.6
1.0 N	0.060	1.119	22.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Norton Reservoir was high at the time the sample was collected (04/15/74). Also, the lack of growth response with the addition of phosphorus alone until nitrogen was also added

indicates the reservoir was nitrogen limited at that time. Note that the addition of nitrogen alone resulted in a yield significantly greater than that of the control.

The reservoir data indicate nitrogen limitation as well. However, primary productivity in the reservoir is intermittently light-limited (Kring, 1977).

Nitrogen limitation, as indicated by the algal assay or by in-reservoir nitrogen to phosphorus ratios, does not necessarily mean that the trophic condition of the reservoir can be improved by controlling nitrogen inputs. In many cases, the apparent condition of nitrogen-limitation results from excessive phosphorus input from point sources and is often accompanied by a corresponding increase in primary production. In such cases, the reversal of the enriched condition depends upon phosphorus control, not nitrogen control.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the months of May and July when two samples were collected. Sampling was begun in November, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in South Prairie Dog Creek at station B-2 and the mean annual ZZ flow.

The operator of the wastewater treatment plant of Jennings did not participate; nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Jennings*	250	stab. pond	94.6	Prairie Dog Creek

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Prairie Dog Creek	8,000	71.9
b. Minor tributaries & immediate drainage (non-point load) -	2,885	25.1
c. Known municipal STP's -		
Jennings	285	2.6
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation** -	155	1.4
Total	11,125	100.0

2. Outputs -

Reservoir outlet - Prairie Dog Creek 2,750

3. Net annual P accumulation - 8,375 kg.

* Anonymous, 1971.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Prairie Dog Creek	41,925	57.0
b. Minor tributaries & immediate drainage (non-point load) -	21,330	29.0
c. Known municipal STP's -		
Jennings	850	1.1
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	9,500	12.9
Total	73,605	100.0

2. Outputs -

Reservoir outlet - Prairie Dog Creek 21,220

3. Net annual N accumulation - 52,385 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Prairie Dog Creek	6	27

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
South Prairie Dog Creek	0.306	2.433

* See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.26	0.95	8.4	6.0

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and 9-year median hydraulic retention time of Norton Reservoir:

"Dangerous" (eutrophic loading)	0.39
"Permissible" (oligotrophic loading)	0.17

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. No. OWP-1, vol. 7, Wash., DC.

Kring, R. Lynn, 1977. Personal communication (revised reservoir morphometry; primary productivity). KS Dept. of Health & Environment, Topeka.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LF E DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] DAYS A	SUR- [illegible] SEX	[illegible] D-[illegible]	[illegible] [illegible]	[illegible] [illegible] [illegible] P
2001	[illegible]	0.017	0.055	[illegible]	[illegible]	[illegible]	[illegible]
2002	COUNCIL GROVE	0.004	0.033	[illegible]	[illegible]	[illegible]	[illegible]
2003	ELK CITY	0.030	0.598	[illegible]	[illegible]	[illegible]	[illegible]
2004	FALL RIVER RESERVOIR	0.053	0.078	[illegible]	[illegible]	[illegible]	[illegible]
2005	JOHN REDMOND RESERVOIR	0.116	1.250	[illegible]	[illegible]	[illegible]	[illegible]
2006	[illegible]	0.056	0.048	[illegible]	[illegible]	[illegible]	[illegible]
2007	[illegible]	0.052	0.038	[illegible]	[illegible]	[illegible]	[illegible]
2008	[illegible]	0.003	0.205	[illegible]	[illegible]	[illegible]	[illegible]
2009	[illegible]	0.079	0.738	[illegible]	[illegible]	[illegible]	[illegible]
2010	[illegible]	0.122	0.133	[illegible]	[illegible]	[illegible]	[illegible]
2011	[illegible]	0.055	0.078	[illegible]	[illegible]	[illegible]	[illegible]
2012	[illegible]	0.040	1.240	[illegible]	[illegible]	[illegible]	[illegible]
2013	[illegible]	0.007	0.025	[illegible]	[illegible]	[illegible]	[illegible]
2014	[illegible]	0.102	0.078	[illegible]	[illegible]	[illegible]	[illegible]
2015	[illegible]	0.023	0.205	[illegible]	[illegible]	[illegible]	[illegible]

LAKES RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]

REPORT OF LAKES WITH HIGH VALUES (NUMBER OF LAKES WITH LOWER VALUES)

LAKE CODE	LAKE NAME	HIGH TOTAL P	HIGH INORG N	SUB-MEAN SEC	HIGH CHLPTA	15- MIN 30	HIGH DISS ORTHO P	INDEX NO
201	[illegible]	100 (14)	100 (14)	100 (14)	93 (13)	57 (8)	89 (12)	539
202	[illegible]	29 (4)	29 (4)	36 (5)	43 (6)	64 (9)	29 (4)	235
203	[illegible]	86 (12)	50 (7)	7 (1)	100 (14)	7 (1)	100 (14)	358
204	[illegible]	57 (8)	57 (8)	14 (2)	71 (10)	79 (11)	50 (7)	328
205	[illegible]	14 (2)	8 (1)	8 (1)	50 (7)	93 (13)	7 (1)	184
206	[illegible]	43 (6)	43 (6)	29 (4)	21 (3)	71 (10)	64 (9)	271
207	[illegible]	64 (9)	64 (9)	42 (6)	29 (4)	86 (12)	71 (10)	357
208	[illegible]	79 (11)	82 (11)	86 (12)	0 (0)	0 (0)	79 (11)	325
209	[illegible]	21 (3)	36 (5)	79 (11)	14 (2)	50 (7)	14 (2)	214
210	[illegible]	7 (1)	93 (13)	94 (13)	7 (1)	100 (14)	21 (3)	292
211	[illegible]	50 (7)	14 (2)	57 (8)	86 (12)	25 (3)	43 (6)	275
212	[illegible]	71 (10)	7 (1)	50 (7)	64 (9)	39 (5)	36 (5)	267
213	[illegible]	36 (5)	71 (10)	21 (3)	79 (11)	39 (5)	57 (8)	303
214	[illegible]	0 (0)	14 (2)	71 (10)	36 (5)	14 (2)	0 (0)	136
215	[illegible]	93 (13)	82 (11)	93 (13)	57 (8)	25 (3)	89 (12)	439

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]

[redacted]

APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]